DRAFT

BA/WTR
C030.00.30
Mail Stop 60189

Memorandum

To: Fishery Biologist, Fish and Wildlife Enhancement, Grand Junction,
        Colorado (65412)
        Attention: Patty Schrader

From: Supervisory Hydrologist, Division of Water Resources

Subject: Depletions at Browns Park National Wildlife Refuge

Recently I was contacted by Mr. Ted Ondler, Assistant Manager at Browns Park
National Wildlife Refuge, who provided me with the information I needed to
complete an analysis of the depletion associated with the operation of Spitzie
Marsh. Apparently the Refuge is planning to move an existing pump several
hundred yards upstream to alleviate maintenance problems caused by sand
deposition at their current pump location. The movement of the pump would not
cause any increase in depletions at Spitzie Marsh.

Future depletions should be the same as historic depletions and I have
estimated these depletions by the use of the indirect method as described in
Attachment A. Evaporation data for Browns Park was obtained from the Colorado
State Engineers Office in Steamboat Springs. The State, in cooperation with
the Refuge, has been maintaining an evaporation monitoring station at Browns
Park for several years and the data should be quite good (Attachment B).

Assumptions:

1. Spitzie Marsh has a maximum surface area of 100 acres and an average
    sustained area of 60 acres. For this analysis, 60 acres of surface area
    was assumed to be present through the entire summer season, since no
    better information was available.

2. Once water is pumped into the Marsh (600 to 1,500 acre-feet annually),
    equilibrium with the river would be reached quickly. Consequently, the
    only depletion loss associated with the Marsh would be evaporation.

3. Since the water pumped each year exceeds the evapo-transpiration estimate of 156 acre-feet, it is assumed that the remainder of the water returns to the river by seepage, and does not result in a net depletion. The amount of seepage that returns to the river will depend upon the hydraulic gradient to the river, that is, the relative levels of the Marsh and the river.

Evaporation Calculations Using 1990 Data:

	Pan Evap - Browns Park	Precip - Browns Park	Net Evap
April	5.48	0.86	4.62
May	7.74	0.43	7.31
June	9.55	1.33	8.22
July	9.31	0.87	8.44
August	8.77	0.08	8.69
September	5.47	0.80	4.67
October	3.54	0.88	2.66
Total			44.61

Net Evap X Pan Coefficient of .70

44.61	X	0.70 =	31.22 inches per year
31.22	X	60.00 acres =	1873.49 acre-inches per year
1873.49	/	12.00 inch/ft =	156.12 acre-feet per year

Conclusion:

1. The pump is being moved to eliminate a maintenance problem caused by sand in the impellers.

2. Both diversions and net depletions at the new pump location will be the same as at the old pump location.

3. Annual diversions (i.e., amount pumped) will range from 600 to 1,500 acre-feet, depending upon climatic conditions and the hydraulic gradient to the river.

4. Annual depletion (i.e., net evaporation) is approximately 156 acre-feet, also dependent upon climatic conditions, but not varying as widely as the annual pumpage.

For further information or questions, please contact me at (303) 236-5322.

Example Problem 5.1 Free Surface Evaporation

A State Water Commissioner is faced with the problem of dispatching and releasing water stored in a mountain reservoir to a downstream diversion point for a water user. He must release more water from storage than will actually arrive at the downstream diversion point. The losses are associated with the evaporation from the stream surface. The centerline distance of the stream is 48.15 miles between the reservoir and the diversion point. The average width of the stream for the anticipated discharge is 110 feet. The mean daily Class "A" tank evaporation for this season is 0.18 inches.

    a) Estimate the mean daily evaporation losses from this stream in acre feet per day.

Problem Solution

Assume that the evaporation pan coefficient to be 0.70 (see Table 5.1).

Then the mean daily free surface evaporation =
= 0.70 x .18 = 0.126 inches/day/unit area.

Surface area of stream = 48.15 miles x 5,280 x 110 =
= 27,965,520 sq ft.
= 27,966,000/43,560 = 642 acres

Evaporation loss = $\frac{642 \times .126}{12}$ = 6.741

say <u>6.74 ac ft/day</u> ⟵——————— a

which can be used to compute the daily lake evaporation given data from daily tank evaporation, the ground level wind, and the maximum and minimum water surface temperature. Average pan coefficient for Class "A" and a number of other evaporation tanks are given in Table 5.1.

Table 5.1

Average Evaporation Pan Coefficients

Location	Period	Class A	Sunken Tanks			
			BPI (1)	Colo. (2)	Young (3)	Symons (4)
Newell Reserv. Canada	1919-25		.95			
Fort Collins Colorado	1926-28	.70		.79		
Denver, Colorado	1915-16	.67				
Denver, Colorado	1916		.94			
Fullerton, California	1936-39	.77	.94	.89	.98	
Lake Elsinore, California	1939-41	.77			.98	
Fort McIntosh, Texas	1950	.72			.89	
Red Bluff Res. Texas	1939-47	.68				
Lake Okeechobee Florida	1940-46	.81		.98		
Lake Hefner, Oklahoma	1950-51	.69	.91	.83	.91	
South Africa						.91

(1) BPI 6 ' dia. x 2' deep, (2) Colo. 3' square x 3' deep, (3) Young Screened 2' dia. x 3' deep, (4) South African Symons 6' square x 2' deep.

COLORADO DIVISION OF WATER RESOURCES DIVISION 6

IRRIGATION CONSUMPTIVE USE & RESERVOIR EVAPORATION DATA COLLECTION PROGRAM 1990

Division 6 personel operated two lysimeters as part of an on going data collection program initiated by the Energy Fuels Corporation in 1978. Both of these lysimeters, an evaporation station, and other meteorological equipment are located along Trout Creek about 10 miles southwest of Steamboat Springs. Evaporation data is also collected by Division 6 personel at Walden along with other data provided to the National Weather Service. We have set up a third evaporation station in Browns Park that is operated by the U.S. Fish and Wildlife Service who also collect data for the National Weather Service at the same site.

The lysimeter tanks are used to collect evapotranspiration data used to estimate depletions resulting from the irrigation of cropland in Division 6. The Lysimeter tanks contain grass sod 18 inches deep and are flooded to ground level generally about once a month during the growing season. The grass in the tanks is harvested about the first of August to simulate local agricultural practices. Flood irrigation is then resumed until the end of the growing season.

The evaporation stations are used to estimate evaporation losses from reservoir surfaces in Division 6. The stations are located at elevations between 5300 and 8100 feet and sample three distinct climate zones in the division. They are operated only during ice-free periods in their respective areas. Water level readings are taken on the evaporation pans usually once a week.

A compilation of collected and computed data is presented in the attached tables 1 thru 8.

WKH
3/22/91
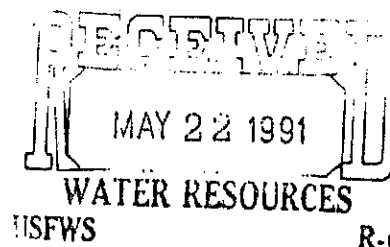
****** TABLE 1 ******

RECORDED CONSUMPTIVE USE 1990

SITE A

Lysimeter Water
Use In Inches

	Precipitation	East Tank	West Tank
MAY	.03	.828	.978
JUNE	.38	3.550	4.129
JULY	1.07	4.422	4.524
AUGUST	.79	4.444	4.956
SEPTEMBER	1.02	1.270	1.540
OCTOBER (1-8)	.10	.040	.050
TOTALS:	4.69	14.550	16.240

****** TABLE 2 ******

SITE A

	Gross ET in Inches East Tank	West Tank	Gross ET in Inches Average of Tanks
MAY (24-31)	.858	1.008	.933
JUNE	3.930	4.572	4.251
JULY	5.492	5.594	5.543
AUGUST	5.234	5.746	5.490
SEPTEMBER	2.290	2.560	2.425
OCTOBER (1-8)	.140	.150	.145
TOTALS:	17.940	19.630	18.790

***** TABLE 3 *****

PARAMETERS RELATED TO IRRIGATION REQUIREMENTS 1990

Month	Mean Temp(F)	Precip (Inches)	Daylite Hours	% Month	(Kp) Blaney-Criddle Crop Coefficient	Average Gross ET (In) Both Tanks	Inches Effective Precip	Irrigation Requirement
JUNE	58.75	.38	10.15	100	.71	4.251	.26	3.95
JULY	62.8	1.07	10.27	100	.86	5.543	.86	4.66
AUGUST	60.77	.79	9.58	100	.94	5.490	.64	4.82
SEPTEMBER	58.38	1.02	8.39	100	.50	2.425	.69	1.75
TOTALS:		3.26				18.642	2.45	15.18

$$Kp = \frac{(GROSS\ ET)\ (10000)}{(TEMP\ F)\ (\%\ DAYLITE)\ (\%\ MONTH)}$$

***** TABLE 4 *****

MONTHLY POTENTIAL NET EVAPOTRANSPIRATION
FOR SELECTED NWS STATIONS 1990

	APRIL	MAY	JUNE	JULY	AUGUST	SEPT	OCT
WALDEN		2.43	4.45	4.04	4.33	2.50	
SPICER		2.36	4.28	4.04	3.71	2.40	
YAMPA		2.27	4.18	2.74	3.02	2.09	.73
STEAMBOAT		1.95	3.35	3.43	2.18	1.66	0.0
HAYDEN		2.58	3.76	4.98	4.48	2.41	.01
CRAIG		2.10	3.69	5.02	4.43	2.90	.13
MAYBELL	1.27	3.16	4.34	5.32	4.68	3.22	1.02
BROWNS PARK	1.59	3.27	4.10	5.21	5.00	2.96	1.20
MARVINE		3.12	3.31	3.56	1.73		
RANGELY	1.80	3.42	4.41	5.73	5.29	3.18	1.01
CYCC		2.27	4.36	4.41	3.92	2.51	.61

These figures represent the total predicted evapotranspiration less the effective precipitation for each month.
This table is produced by using Blaney_Criddle methology as described in SCS Technical Release 21 with the following
adjustments for crop coefficients: Ka= Average seasonal crop coefficient. Ka= .71 (.81 for Spicer and Walden).
Kp= Monthly crop coefficient. Kp= Ka + .75 cos [(month - 7) / 3] - .64. (All % daylite hours @ 40 N. Lat).

****** TABLE 5 ******

DIVISION 6 LYSIMETER PROGRAM
MONTHLY BLANEY - CRIDDLE CROP COEFFICIENT SUMMARY

	MAY	JUNE	JULY	AUG	SEPT	OCT
1979 (EP Data)	.81	.77	1.39	1.05	.81	.74
1980 (EP Data)		1.06	.99	1.42	1.16	1.13
1983	.75	.83	.72	.89	.74	.88
1984		1.08	1.07	.98	.77	.43
1985	.83	1.09	.91	.76	.96	
1986		1.01	1.04	.73	1.03	
1987		.89	.99	.94	.79	.46
1988		.88	.85	.77	.78	
1989	.80	.89	.96	.82	.86	
1990		.73	.86	.94	.50	
AVERAGE	.80	.92	.98	.93	.84	.73

****** TABLE 6 ******

1990 MONTHLY PAN EVAPORATION (Inches)

	Walden (8115 ft)	Colo Yampa Coal (6670 ft)	BROWNS PARK (5354 ft)
APRIL	1.067(18-30)	.519(23-30)	5.481
MAY	5.524	5.271	7.736
JUNE	8.763	4.474	9.55
JULY	6.646	7.315	9.31
AUGUST	6.407	6.688	8.77
SEPTEMBER	4.751	5.390	5.47
OCTOBER		.824(1-8)	3.54

****** TABLE 7 ******

1990 TEMPERATURE AND PRECIPITATION

	Walden		Colo Yampa Coal		Browns Park	
	Temp	Precip	Temp	Precip	Temp	Precip
APRIL	38.2	1.05			50.6	.86
MAY	42.98	1.18	43.6	.88	53.9	.43
JUNE	55.7	.64	57.75	.38	65.4	1.33
JULY	58.5	1.87	62.8	1.07	70.75	.87
AUGUST	56.6	.56	60.77	.79	67.1	.08
SEPTEMBER	53.7	1.29	58.38	1.02	63.95	.8
OCTOBER	53.9	1.85			47.9	.88

****** TABLE 8 ******

1990 RESERVOIR EVAPORATION (Net Depletion In Inches)

Gross Evaporation Less Effective Precipitation

	EVEV	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	TOTAL
WALDEN RES	8060	(1.5)	2.84	5.54	2.97	3.96	2.16	(1.0)	19.97
MEADOW CK RES	8540		2.57	5.15	2.71	3.01	1.79	(1.5)	16.73
YAMCOLO RES	9500		1.78	1.63	.49	1.14	.69		5.73
LAKE CATAMOUNT	6900	(1.0)	2.48	1.51	2.70	1.59	1.44	(1.0)	11.72
STEAMBOAT LAKE	8030		2.46	1.49	2.71	1.62	1.44	(1.0)	10.72
ELKHEAD RES	6380	(1.5)	2.95	2.22	4.95	4.72	3.53	(1.5)	21.37
LAKE AVERY	6985	(1.0)	2.67	1.81	3.40	3.85	2.13	(1.0)	15.86
TAYLOR DRAW RES	5315	3.4	5.31	5.88	6.33	6.55	3.49	1.52	32.48